Renewed Electromagnetism

by the Energy Circulation Theory

Version-2024.10

Renewed concepts for

Electric Charge, Electric Current, Magnetic Charge

Key features:

- Electric charge: Momentum in the hidden dimension of the 4D space
- Electric current: Not a movement of electrons, but a transduction of electric polarization energy
- Magnetic charge: Momentum in the 3 space dimensions of hidden-space dimensional energy circulations

Problems of the existing Electromagnetism (EM)

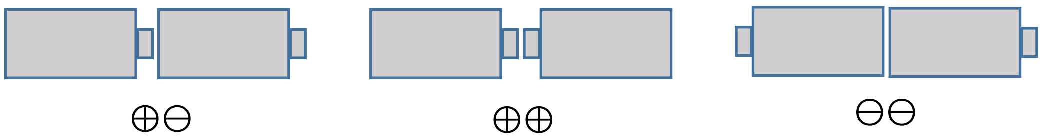
Electric charge:

- Origin of electric charge is disregarded. Assumed unconditionally.
- Elementary charge $\pm e$ are localized at electron and proton (point charge).

Electric force:

$$F = K\frac{Q_1 Q_2}{d^2}$$

- Attractive force between electron and proton in an atom
- Is there really other example of electrostatic forces?
- Between electrodes of different cells, we **cannot** detect a force. **Critical**



Electric current:

- Passage of electric charge at a cross section. $I = Q/t$
- Said to be a movement of electrons. **Is it true?**
- Drift speed of electrons is at a sub-mm/sec level.

Electric charge and force by the ECT

Fundamental force works based on **momentums** (vector charge).

$$F = K_f \frac{{}^{\square}_{\mathbf{r}}\mathbf{p_1} \cdot {}^{\square}_{\mathbf{r}}\mathbf{p_2}}{d^2} = K_f \frac{p_1 p_2}{d^2} \cos\theta_p \sin\theta_1 \sin\theta_2$$

Elementary single circulation iS in **hidden-space** dimensions:

Energy magnitude: $E_{(iS)} = m_0 {v_c}^2 = m_0 {\mu_0}^2 {\omega_0}^2 = m_0 c^2$

Energy location: $\psi_0 = \mu_0(\cos\omega_0 t + i \sin\omega_0 t)$

Space-directional force between two halves:

$$F_x = -\frac{8}{\pi^2} K_f \frac{{p_h}^2}{(2\mu_0)^2} = -K_e \frac{e^2}{(2\mu_0)^2} = -K_e \frac{e^2}{d^2}$$

μ_0: radius, ω_0: frequency, p_h: momentum of half-circle

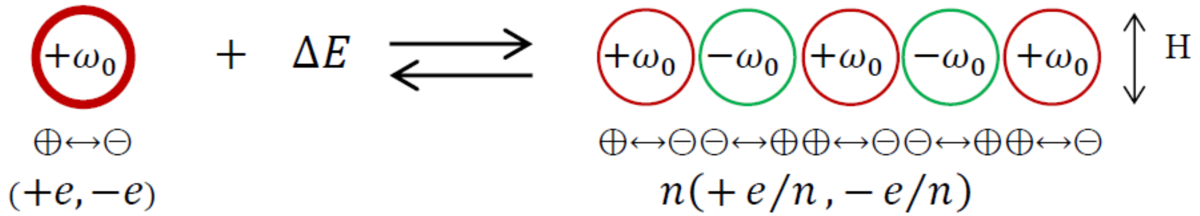
Momentum in the **hidden Dimension**:

- Orthogonal to any directions in 3D. $\cos\theta_p \sin\theta_1 \sin\theta_2 = \pm 1$
- Can be treated as a scalar charge, defined as the **electric charge**.

Elementary charge: $e \equiv p_h = m_0 \mu_0 \omega_0 / 2 = m_0 c / 2$

Prolongation of iS and connected electric force

By addition of energy, iS prolongs to plural spacias in a space direction.



Electric charge = momentum in the hidden dimension H

Circulating energy / momentum in H-X: Not change

Potential energy in X: Increase

Call the prolonged iS as the **elementary charge pair** (**eCP**)

Intra-circulation force between 2 halves in one circulation of an eCP:

$$F_x = \frac{8}{\pi^2} K_f \frac{(p_h/n)(-p_h/n)}{(2\mu_0)^2} = -\frac{8}{\pi^2} K_f \frac{{p_h}^2}{(2n\mu_0)^2} = -K_e \frac{e^2}{d^2}$$

Forces at junctions of spacias inside: Set off as zero

The force affects only at the two ends.

Same as virtual force between $\pm e$ with distance $d = 2n\mu_0$

Maximum electric charge and non-connected electric force

In the **standard EM**:

- Elementary charge e is the **minimum** charge.
- Its cluster $q = \pm ne$ is possible as an isolated electric charge.
- Between cluster charges, electrostatic force works.

From the **Energy Circulation Theory**:

- Elementary charge e is the **maximum** charge. Greater charge impossible.
- Electric charge at the two ends of an eCP = $\pm e/n$ $(n = 10^4$ in atom)
- Inside eCP, $+2\,e/n$ and $-2\,e/n$ lye by turn.
- Non-connected electric force (electrostatic force) between two charges is possible only at an end of an eCP and only for a very short distance like some times of μ_0.

For usual macroscopic observations we can regard:

Isolated **electric charges** do **not exist** for electrostatic force.

Energy of eCP

By absorbing light, eCP prolongs. $eCP(x+\Delta x) \rightleftarrows eCP(x) + \gamma$

$$E_{(n-iS)} = m_0 c^2 + \Delta E$$

ΔE = increase in electric potential energy. Set the potential energy at $x = 2\mu_0$ as the energy of iS.

$$U(2\mu_0) \equiv E_{(iS)} = m_0 c^2$$

Energy of $eCP(x)$:

$$\Delta E = U(x) - U(2\mu_0) = \int_{2\mu_0}^{x} (-F_x) dx = \int_{2\mu_0}^{x} K_e \frac{e^2}{x^2} dx$$

$$U(x) = \Delta E + U(2\mu_0) = K_e e^2 \left(\frac{1}{2\mu_0} - \frac{1}{x} \right) + m_0 c^2 \quad (x \geq 2\mu_0)$$

For an eCP,

Polarization energy ≡ electric potential energy = total energy

Free electron and proton

Maximum energy of addition for prolongation of eCP:

$$\Delta E = U(x+\Delta x) - U(x) = K_e e^2\left(\frac{1}{x} - \frac{1}{x+\Delta x}\right), \qquad \Delta E_{max} = \frac{K_e e^2}{x}$$

Absorbed higher energy of light than the maximum, it divides to two eCPs.

$$eCP(x) + \Delta E \longrightarrow eCP(x_1) + eCP(x_2)$$

Hydrogen atom: Adduct of an eCP with a neutrino at the minus end and with an $\overline{S}$ at the plus end accompanied by D and $D^{\#}$ (excited form of D)

$$p^+\left(D^{\#}, D, \overline{S}, iH_+\right) \cdots e^-(H, iH_-)$$

Ionization to a **free electron** and **free proton**: By absorbed light with higher energy than the maximum, the eCP divides to two ones.

$$p^+\left(D^{\#}, D, \overline{S}, iH_+\right) \cdots e^-(H, iH_-) + \Delta E \longrightarrow p_f\left(D^{\#}, D, \overline{S}, eCP\right) + e_f(H, eCP)$$

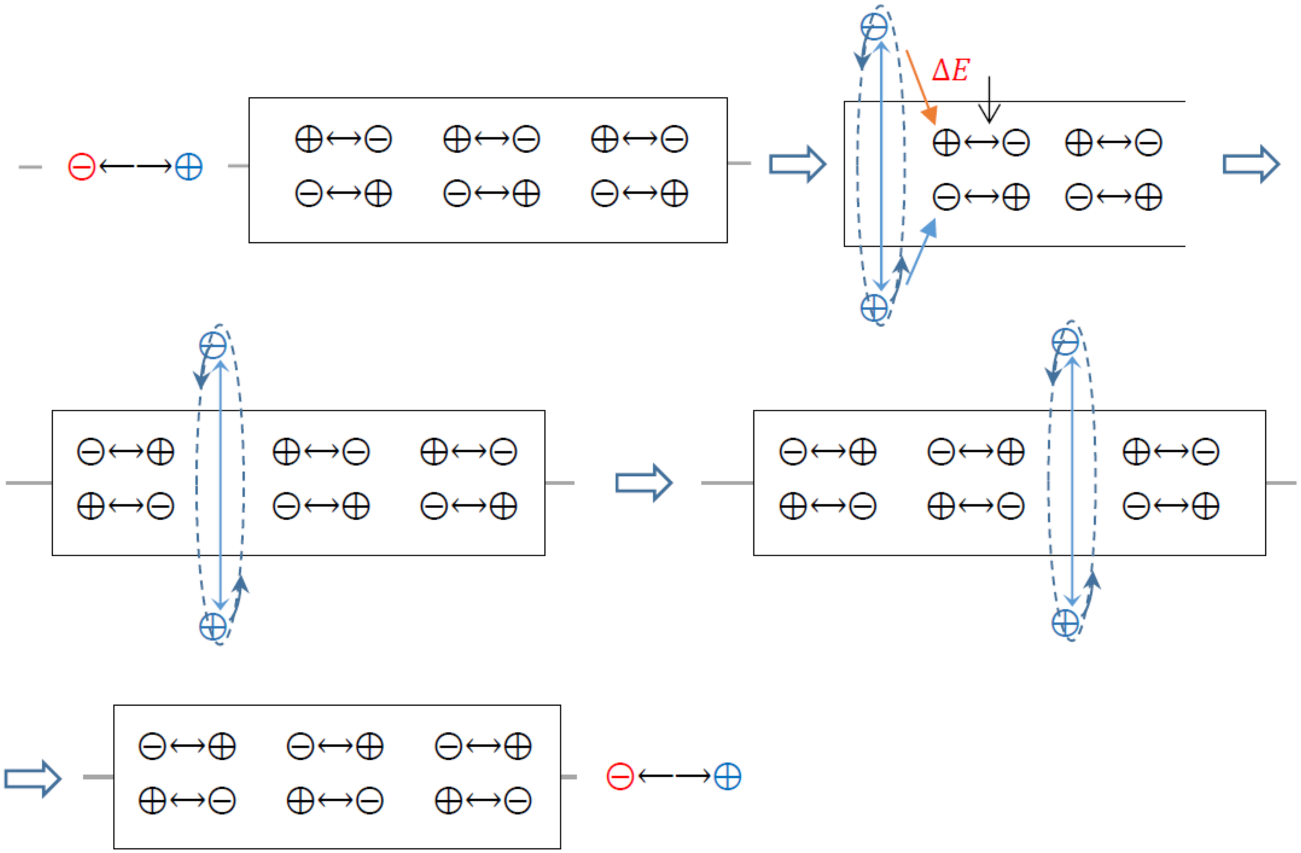
one eCP $(iH_+ \cdots iH_-)$ $\longrightarrow$ two eCPs

Both free electron and free proton (ions) are electrically **neutral**.

Electric current

Electric current: Transduction of electric polarization by rearrangement of pairing of elementary charge pairs (eCPs)

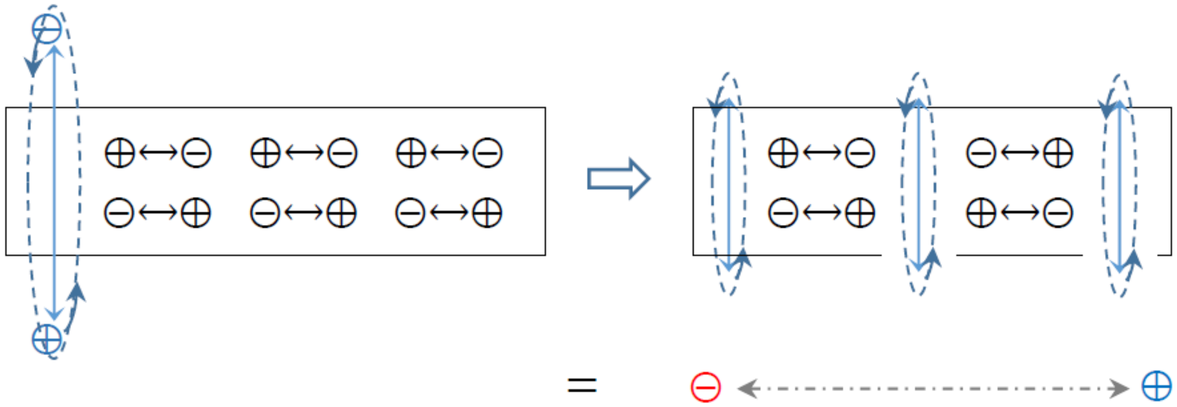
Local unit in a conductor: plus-minus and minus-plus conjugate of eCPs



Polar potential V_p: Define as the sum of electric potential energies $U(x_i)$ of eCPs in a single series connection (**unit line**)

$$V_p \equiv \left| \sum_i U(x_i)\mathbf{e_i} \right| \text{ in a unit line}$$

$\mathbf{e_i}$: unit vector in curvilinear coordinates ($+1$ or -1)



Addition of eCP to a non-connected conductor. The electric polarization of the eCP spreads to the whole length. The polar potential is independent of length.

Total electric potential energy U (m: number of unit lines):

$$U = mV_p$$

Polar charge $\mathbf{C_p}$: Define as the sum of polarization vectors of eCPs in a conductor based on the electric potential energy

$$\mathbf{C_p} \equiv \sum_i U(x_i)\mathbf{e_i}/U_0 = C_p \mathbf{e_p} = \begin{cases} +C_p \\ -C_p \end{cases}, \qquad U_0 \equiv U(2\mu_0) = E_{(iS)} = m_0 c^2$$

$$C_p U_0 = U = mV_p$$

$\mathbf{e_p}$: plus or minus, take + for the direction from - to + of eCP

Electric current $\mathbf{I_p}$: Define as the polar charge $\mathbf{C_p}$ that passes through a cross section of a conductor during a unit time (second)

$$\mathbf{I_p} \equiv \mathbf{C_p}/t \ , \qquad \left(I_p = C_p/t\right)$$

$$I_p U_0 = C_p U_0/t = U/t = P \ \text{(power)}$$

Current potential V_c: Define as the power (energy/time) in a unit line

$$V_c \equiv P/m = I_p U_0/m \ , \qquad P = U/t = mV_c$$

Comparison with standard EM

1) Electric charge

$Q \quad \Rightarrow \quad$ Not used for current. $Q = (+e) + (-e) = 0$ for an eCP

2) Electric potential energy: U

3) Polar charge

None $\quad \Rightarrow \quad C_p = U/U_0 \quad$ (U_0: energy of iS)

4) Electric current

$$I = Q/t \quad \Rightarrow \quad I_p = C_p/t$$

5) Power

$$P = U/t = IE \quad \Rightarrow \quad P = U/t = I_p U_0$$

6) Number of unit lines

None $\quad \Rightarrow \quad m$

7) Electromotive force

(Volt as unit) $\quad$ Current potential (power of a unit line)

$$E(V) = P(W)/I(A) \quad \Rightarrow \quad V_c = P/m = I_p U_0/m$$

8) Electrostatic potential

Electric potential $\quad$ Polar potential (electric potential energy of a unit line)

$$V = U/Q \quad \Rightarrow \quad V_p = U/m$$

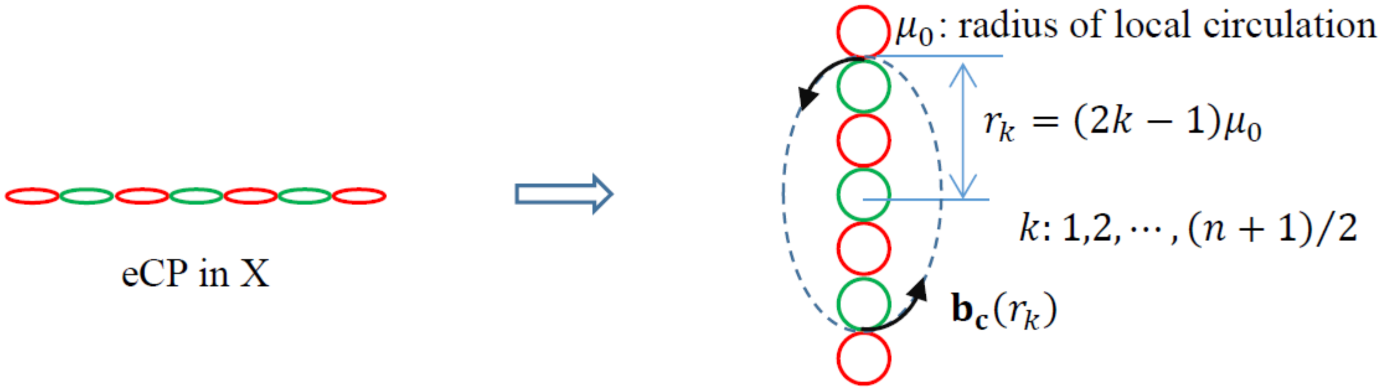
Magnetic charge

Magnetic charge: Define as the momentum in space dimensions of hidden-space dimensional circulations. $\mathbf{b}$: vector charge

$$F = K_f \frac{b_1 b_2}{d^2} \cos\theta_p \sin\theta_1 \sin\theta_2$$

Static eCP: Magneti charge is zero $\mathbf{b} = +b - b = 0$ in x

Rotating eCP (**magnetic rotation**) around the **hidden H axis**:



Magnetic rotation: rotating eCP in Y-Z

Motion in **space** dimensions:

Helical **Linear** motion in YZ-X ⇒ Helical **rotation** in XY-Z

$$V_{major}^2 + V_{local}^2 = r^2\omega^2 + {\mu_0}^2{\omega_x}^2 = c^2$$

Magnetic rotation

Energy location for **Major** Rotation in Y-Z:

$$[Y \quad Z]_k = r_k[\cos\omega t \quad \sin\omega t] = r_k \exp(i\omega t)$$

$$\psi_k = [L_0 \quad L_\pi]_k = r_k\left[\exp(i\omega t) \quad \exp\left(i(\omega t + \pi)\right)\right] = r_k \exp(i\omega t)[1 \quad -1]$$

$$r_k = (2k-1)\mu_0 \,, \qquad k: 1,2,\cdots \leq (n+1)/2$$

Energy magnitude:

$$E_k = \frac{E}{n} = \frac{mc^2}{n} \quad \text{for } k = (n+1)/2$$

$$E_k = \frac{2E}{n} = \frac{2mc^2}{n} \quad \text{for } k < (n+1)/2$$

Rotating magnetic charge:

$$\mathbf{b_c}(r_k) = \frac{2m}{n}\mathbf{v_c} = \frac{2m}{n} r_k \omega \mathbf{e_c} \quad \text{for } k < (n+1)/2$$

$$\mathbf{b_c}(r_k) = \frac{m}{n}\mathbf{v_c} = \frac{m}{n} r_k \omega \mathbf{e_c} \quad \text{for } k = (n+1)/2$$

$\mathbf{e_c}$: Unit vector of any arc on circumference

Magnetic charge density

Linear density of magnetic charge:

$$\oint \mathbf{b_L}(r_k)dl = 2\pi r_k \mathbf{b_L}(r_k) \equiv \mathbf{b_c}(r_k)$$

$$\mathbf{b_L}(r_k) = \frac{m}{\pi n}\omega \mathbf{e_c} \text{ for } k < (n+1)/2 \,, \qquad \mathbf{b_L}(r_k) = \frac{m}{2\pi n}\omega \mathbf{e_c} \text{ for } k = (n+1)/2$$

Gross magnetic charge: Define as the sum of magnetic charges of the all radiuses from r_1 to $r_{(n+1)/2}$

Linear density of gross magnetic charge:

$$\boldsymbol{\beta}_{\mathbf{L}} = \frac{n-1}{2}\frac{m}{\pi n}\omega \mathbf{e_c} + \frac{m}{2\pi n}\omega \mathbf{e_c} = \frac{m}{2\pi}\omega \mathbf{e_c} = \frac{E}{2\pi c^2}\omega \mathbf{e_c}$$

Energy of electric current of a **unit line** in length Δx is $Pt = P\,\Delta x/c$.

$$E(\Delta x) = I_p U_0 \frac{\Delta x}{c}$$

$$\boldsymbol{\beta}_{\mathbf{L}}(\Delta x) = \frac{E(\Delta x)}{2\pi c^2}\omega \mathbf{e_c} = \frac{I_p U_0 \Delta x}{2\pi c^3}\omega \mathbf{e_c} \text{ (in length } \Delta x)$$

Surface density of gross magnetic charge:

$$\boldsymbol{\beta}_{\mathbf{S}} \equiv \frac{\boldsymbol{\beta}_{\mathbf{L}}(\Delta x)}{\Delta x} = \frac{U_0}{2\pi c^3} I_p \omega \mathbf{e}_{\mathbf{c}} = \frac{m_0}{2\pi c} I_p \omega \mathbf{e}_{\mathbf{c}}$$

Express by rotation around electric current.

$$\nabla \times \boldsymbol{\beta}_{\mathbf{S}} = \frac{m_0}{2\pi c} \omega \mathbf{I}_{\mathbf{p}}$$

Gross magnetic charge: $\boldsymbol{\beta}(\Delta s) = \Delta l \Delta x \boldsymbol{\beta}_{\mathbf{S}} = \Delta s \boldsymbol{\beta}_{\mathbf{S}}$

In a conductor consisting of **multiple unit lines**

Magnetic charges: set off as **zero inside**, appear **only on surface**

Surface density of gross magnetic charge on the surface of conductor:

$$\nabla \times \boldsymbol{\beta}_{\mathbf{S}} = \frac{m_0}{2\pi c} \omega \frac{\mathbf{I}_{\mathbf{p}}}{m} \quad (m\text{: number of unit lines})$$

Proportional to the rotating **frequency** and **electric current density**.

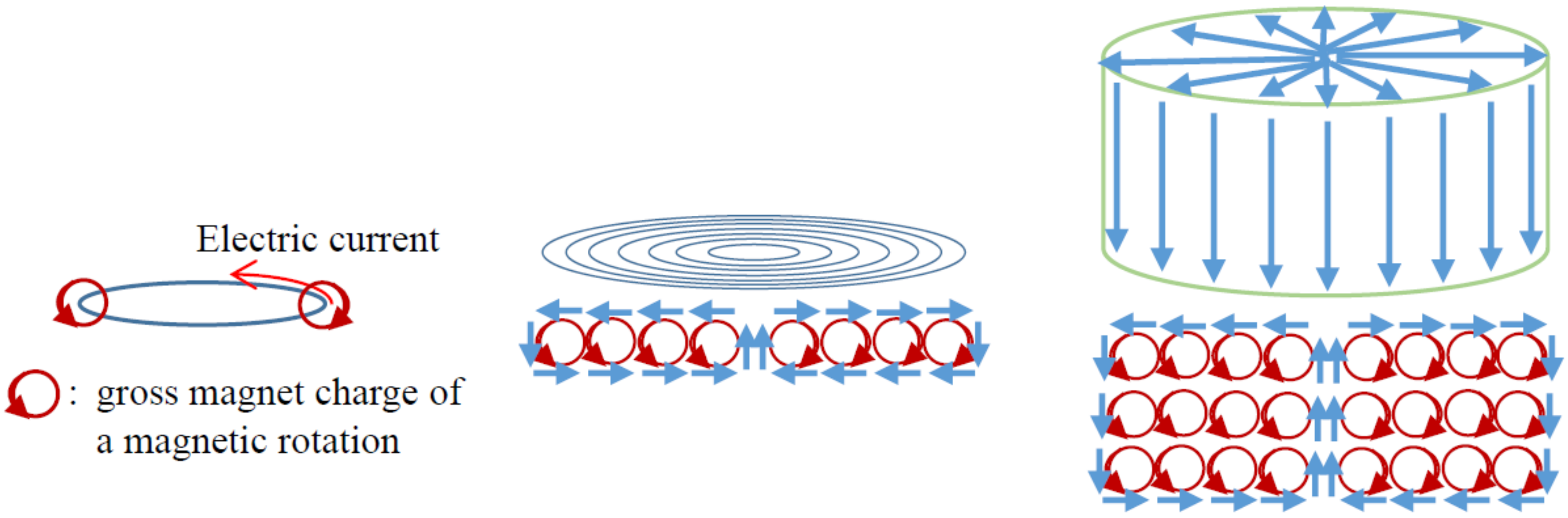
Standard EM: $\nabla \times \mathbf{H} = \mathbf{j}$ ($\mathbf{H}$: magnetic field, $\mathbf{j}$: electric current density)

Magnet

Unit magnet: Closed unit line (circuit) with electric current

Unit layer of magnet: Concentric unit magnets in a plane

Brock magnet: Assemble of unit magnet layers



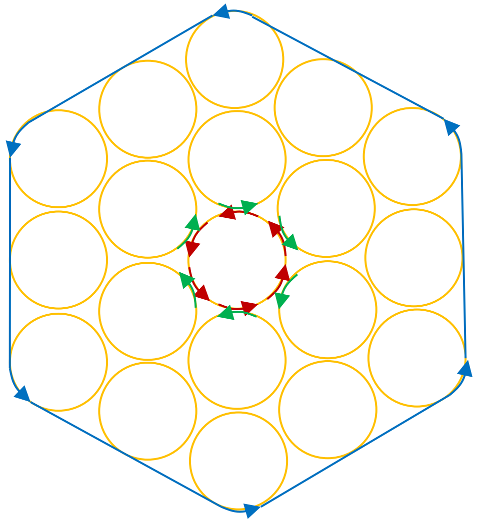
(a) unit magnet (b) unit layer of magnet (c) brock magnet

Magnetic interactions of charged bodies

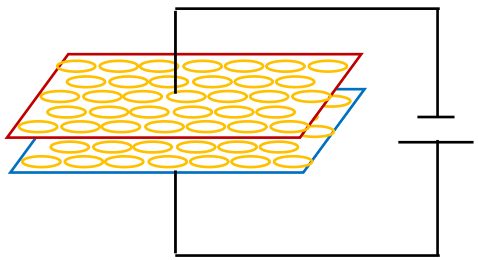
Electrification: Not an excess of positive or negative electric charges
But the energy of free eCPs is accumulated

Charged body: An isolated conductor with free eCPs accumulated (Fig on p9)

Cross section of charged body



(a) Cross section of charged body (= electrode plane)



(b) Capacitor

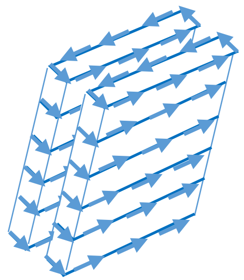
The individual circles indicate the magnetic rotation around a unit line. The **rotating magnetic charges** are set off to zero inside, and **remain** only on the **outer surface**.

Magnetic force acting on side surfaces of charged body

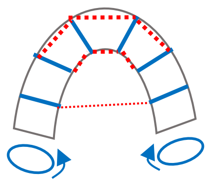
On electrode surface (cross section): Magnetic force does not work.

On **side surface**: Rotating magnetic charges remain → magnetic interaction

Interaction of side faces of charged bodies and magnetic action inside a curved charged body



(a) Magnetic interaction of side faces of charged bodies



(b) Magnetic action inside a curved charged body

(a) Between two flat charged bodies, attraction works at their sides. (b) In a curved charged body, distances between rotating magnetic charges are shorter on inside than on outside, and repulsive forces on inside are larger.

Examples of (b): Hair raising due to so called the static electricity. The two ends spread out when a folded piece of aluminum foil is charged.

Discharge of a charged body

Electric discharge: Not the movement of electrons

But the **movement** of free **eCPs**

Free **eCPs**: Exist as **magnetic rotations** in a **conductor** (charged body).

Move linearly in helical rotation in the **space**.

Discharge in the **vacuum space** (filled with spacias):

- eCPs can transmit in spacias (coupled conjugate pairs in hidden-space D).
- Directions of circular and linear movements can be flexible.

  Transmitting direction of eCP can change.
- Magnetic rotation (in a matter) → Linear motion → magnetic rotation (p8)

  Not all energy of magnetic rotation is transferred to the next rotation.
- Electric discharge in air transmits in **zigzag**, accompanied by **lightning**.

Electron beam:

- Motion of a free electron $e_f(H, eCP)$ (neutrino attached to eCP).
- Moves **linearly** in the vacuum due to the **inertia** of **neutrino**.

Published paper:

S. Nagao, Renewed Concepts for Electric Charge, Electric Current and Magnetic Charge by the Energy Circulation Theory, *Rep. Adv. Phys. Sci.* **7** (2023) 2350008.

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Website:

Energy Circulation Theory (ECT) home

Novel electromagnetism by the ECT